

II. Objection To Oath Or Declaration.

The Examiner in the official office action dated June 13, 2002 objected to the oath or declaration as not being in compliance with 37 CFR 1.67 (a). Acknowledgment of this objection is noted. Applicants will submit a new oath and declaration in compliance with 37 CFR 1.67 (a).

III. Election/Restrictions

The Examiner states that the Applicants' argument with regard to the restriction requirement has been found persuasive and thus claims 1-14 will be examined. Regarding the election of species the Examiner found Applicant's argument to be not persuasive. While Applicants believe that the etiology of the diseases listed in claim 13 are from an elevated blood glucose, no further discussion is necessary.

IV. Objection To Disclosure.

Further objection was made to informalities within the disclosure. The Examiner states that the specification uses the bracket [...] in the text. Applicants have amended the specification correcting this informality and others and thank the Examiner for her diligence in the examination of the instant application and suggested changes. These amendments to the specification were merely to correct informalities and have added no new matter to the disclosure.

The Examiner also states that the specification indicates H-Val-Pro-CH₂(N⁺C₅H₅) has a short half life of 13.3 min in Table 1 (page 18), however, it also indicates it is stable over 24 hours under the same conditions (page 18, lines 5-7). Applicants have amended paragraph one

on page 18 to more clearly emphasize that when H-Val-Pro-CH₂(N⁺C₅H₅) is prepared according to the invention by the masking of the compound it is much more stable than the unmasked version of H-Val-Pro-CH₂(N⁺C₅H₅). This amendment to paragraph one on page 18 was merely to correct informalities and has added no new matter to the disclosure.

V. Claim Objections.

Objection was made to claims 1 and 4 due to informalities within the claim language. Applicants have amended claims 1 and 4 to correct these informalities and thank the Examiner for the suggested changes.

VI. Claims 11-13 Rejected Under 35 USC 112 First Paragraph

Rejection was made to claims 11-13 under 35 USC 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time of the application was filed, had possession of the claimed invention. Applicants have considered the Examiner's rejection but must respectfully traverse this rejection. The Examiner suggests that the specification has not demonstrated the use of the tetrapeptide Gly-Pro-Val-Pro-CH₂(N⁺C₅H₅)Cl in treating diabetes mellitus. The Applicants would respectfully suggest that it is not required to demonstrate the use of a compound under the provision of 35 USC 112, first paragraph. The written description requirements generally require Applicants to describe the invention to one of ordinary skill in the art. The CCPA has stated that "[n]ot every last detail is to be described, else patent specification would turn into production specifications, which they were never intended to

be.” In re Gay, 309 F.2d 769, 135 USPQ 311, 316 (C.C.P.A. 1962). The Applicants must merely provide sufficient detailed as to allow a person skilled in the art the ability to practice the invention.

The Examiner further suggests that Applicants have not indicated the treating conditions such as the dose, method of administration and the effect of the compound. Applicants would respectfully suggest that it has disclosed within the specification a method of administration. (see specification page 5 line 5-7), dosing (see specification page 8 line 32-33. page 9 line 14-18) and the effect of the compound (see specification page 5 lines 8-11). Claim language must be read in light of the specification as it would be interpreted by one of ordinary skill in the art. In re Moore, 58 CCPA 1042, 1046-1047, 439 F.2d 1232, 1235, 169 USPQ 236, 238 (1971). The Applicants would respectfully submit that it has more than met the requirements of 35 USC 112 for claim 11-13 and would therefore respectfully request that this rejection be withdrawn.

VII. Claim Rejections 35 USC 112

The Examiner rejected claims 1-3, 5, 6 and 8-13 under 35 USC 112 second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants regard as their invention. Applicants have considered the Examiner’s rejection and have amended claim 1 to more clearly define and emphasize the Applicants’ invention. The amendment to claim 1 places claims 2-3, 5-6 and 8, which depend from claim 1, in suitable form thereby meeting the requirements of 35 USC 112. Applicants have also amended claims 9 and 11 from which all other rejected claims depend to further define and emphasize Applicants’ invention. Applicants respectfully request that this rejection be withdrawn.

Further rejection was made to claims 2 and 4 under 35 USC 112 as being indefinite because of the improper phrasing of a Markush group. Applicants have amended claim 2 and 4 as the Examiner has suggested. Applicants thank the Examiner for the suggested amendment.

Rejection was also made to claims 4, 7 and 14 as being indefinite because of the term dipeptide derivative. The Examiner states that it is unclear how different the derivative is from the parent compound. Applicants have considered the Examiner's rejection but respectfully traverse this rejection. Within the specification, Applicants clearly define a dipeptide derivative as having an active carbonyl group at the C-terminus. The unstable inhibitor represented by C within the general formula is further described as a "dipeptidyl chloroalkyl ketone, dipeptidyl boronic acid or dipeptidyl cyanide compound or dipeptidyl pyridinium methyl keto compound (Specification page 8 line 19-25). Contrary to the Examiner's rejection, the specification clearly defines the metes and boundaries of Applicants' claimed invention and therefore the Applicants would respectfully request the withdrawal of this rejection.

Further rejection under 35 USC 112, second paragraph was made regarding claims 9 and 10. The Examiner states that the claims as presented lack the omitted step of the preparation of the pharmaceutical composition from the compound of A-B-C. Applicants thank the Examiner for the suggested amendment and have amended claim 9 to more clearly define and emphasize the claimed invention.

Further rejection under 35 USC 112, second paragraph was made regarding claims 11-13. The Examiner states that the claims as presented lack the omitted steps of the effective amount of the compound used and the method of administration and the outcome for the treatment. Applicants traverse this rejection. Applicants respectfully disagree that claims 11-13 are

indefinite as suggested by the Examiner. As set forth in the specification, a distinct advantage of the instant invention is that each organism will release the exact amount of inhibitor that is necessary to inhibit the amount of DP IV that is present, which is different in individual cases. If for example a patient has a high concentration of DP IV then a large amount of inhibitor will be released, if there is only a slightly elevated concentration of DP IV, only a small amount of inhibitor will be released. Applicants respectfully suggest that claims 11-13 meet the requirements of 35 USC 112 in light of the specification and would therefore respectfully request that this rejection be withdrawn.

Further rejection was made to claim 13 as being directed to non-elected diseases. Claim 13 has been amended to more clearly define and emphasize Applicants' invention. Applicants would respectfully request that this rejection be withdrawn.

VIII. Rejection of Claims 1-3, 5 and 8-12 under 23 USC 102(b)

The Examiner further rejected claims 1-3, 5 and 8-12 under 35 USC 102 (b) as being anticipated by Bachovchin et al. WO 93/08259 (Bachovchin). The Examiner states that Bachovchin discloses that dipeptides having boroPro moiety as DP IV inhibitors are relatively unstable. Applicants respectfully suggest that the claims as amended are no longer anticipated by Bachovchin and would therefore respectfully request that this rejection be withdrawn.

IX. Rejection of Claims 1-3, 5 and 7-11 under 23 USC 102(b)

The Examiner rejected claims 1-3, 5 and 7-11 under 35 USC 102 (b) as being anticipated by Bachovchin et al. WO 95/11689 (Bachovchin). The Examiner states that Bachovchin


discloses that dipeptides having boroPro moiety as DP IV inhibitors are relatively unstable, but the tetrapeptides such as X-Pro-Y-boroPro, where X and Y are chosen from any amino acid including Pro, function as DP IV inhibitors because the dipeptide portion is a substrate of DP IV and the final product is the dipeptide inhibitor Y-boroPro. Applicants respectfully suggest that the claims as amended are no longer anticipated by Bachovchin and would therefore request that this rejection be withdrawn.

CONCLUSION

Applicants respectfully request expeditious consideration and passage of the present application to issuance. The Examiner is invited and encouraged to telephone the undersigned if he believes such would facilitate prosecution of the present application.

In accordance with 37 CFR 1.21 (c) (1) (ii) a marked up version of the amended claim(s) is attached as Appendix A and a marked up version of the amended specification is attached as Appendix B.

Respectfully submitted,



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APPENDIX A

1. (TWICE AMENDED) Compounds of inhibitors of the enzymatic activity of dipeptidyl peptidase IV (DP IV), which compounds have the general formula A-B-C, wherein

A is an amino acid,

B is a chemical bond between A and C or is an amino acid, and

C is an unstable inhibitor of DP IV wherein said unstable inhibitor is a dipeptide derivative having an C-terminus with an active carbonyl group.

2. (TWICE AMENDED) Compounds according to claim 1, wherein B is selected from the group consisting of proline, hydroxyproline, thiazolidinecarboxylic acid, dehydroproline, pipecolic acid, azetidinecarboxylic acid [or] and aziridinecarboxylic acid.

4. (TWICE AMENDED) Compounds according to claim 1 wherein said unstable inhibitor is a dipeptide derivative having an active carbonyl group at the C-terminus selected [form] from the group consisting of [is] Ile-Thia, Ile-Pyr, Val-Thia [or] and Val-Pyr.

9. (TWICE AMENDED) A method of preparing a pharmaceutical composition for the temporally controlled *in vivo* enzymatic inhibition of DP IV comprising providing a compound of the general formula A-B-C, wherein

A is an amino acid

B is a chemical bond between A and C or is an amino acid, and

C is an unstable inhibitor of DP IV wherein said unstable inhibitor is a dipeptide derivative having a C-terminus with an active carbonyl group; and
preparing a pharmaceutical preparation containing said compound and customary
pharmaceutical carriers or excipients

11. (TWICE AMENDED) A method of treating disorders in mammals that can be treated by modulating the DP IV enzymatic activity of a mammal comprising the step of administering to said mammal a compound of the general formula A-B-C, wherein

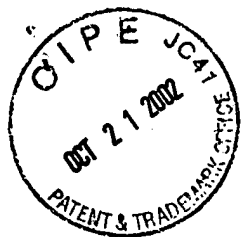
A is an amino acid

B is a chemical bond between A and C or is an amino acid, and

C is an unstable inhibitor of DP IV wherein said unstable inhibitor is a dipeptide derivative having a C-terminus with an active carbonyl group.

13. (TWICE AMENDED) The method of claim 11 wherein said compounds are used to treat impaired glucose tolerance, [glucosuria, hyperlipidaemia, metabolic acidoses, obesity,] diabetes mellitus, diabetic neuropathy and nephropathy and sequelae of diabetes mellitus in mammals.

14. (AMENDED) A compound of claim 1 wherein said unstable inhibitors are selected from a group consisting of a dipeptidyl alkyl ketone derivative, with a fluoro alkyl ketone derivative being exempted from the dipeptidyl alkyl ketone derivatives, a dipeptidyl chloroalkyl ketone, dipeptidyl cyanide [or a] and dipeptidyl pyridinium methyl ketone radical



APPENDIX B
MARKED UP SUBSTITUTE SPECIFICATION
COMPOUNDS OF UNSTABLE DP IV-INHIBITORS
CROSS REFERENCE TO OTHER APPLICATIONS

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The present application is claiming priority of DE 19828114.5 filed on June 24, 1998 and subsequent PCT EP 99/04381 application filed on June 24, 1999.

BACKGROUND OF THE INVENTION

Aminoacyl thiazolidides, aminoacyl pyrrolidides, N-dipeptididyl, O-acyl hydroxylamines and other compounds are known to act as inhibitors of the serum enzyme dipeptidyl peptidase IV (DP IV) and of analogous enzymes {{see DEMUTH, H.-U., J. Enzyme Inhibition 3, 249 (1990); DEMUTH, H.-U., HEINS, J., in *Dipeptidyl Peptidase IV* (B. Fleischer, Ed.) R.G. Landes, Biomedical Publishers, Georgetown, 1995, 1-37}}.

It has been found that the T-cell-mediated immune response, for example in the case of transplantations, is influenced by means of stable inhibitors of dipeptidyl peptidase IV, {{see KOROM, S., DEMEESTER, I., STADLBAUER, T.H.W., CHANDRAKER, A., SCHAUB, M., SAYEGH, M.H., BELYAEV, A., HAEMERS, A., SCHARPE, S., KUPIEC-WEGLINSKI, J.W., Inhibition of CD26/dipeptidyl peptidase IV activity in vivo prolongs cardiac allograft survival in rat recipients, Transplantation 63, 1495 (1997)}}. Rheumatoid arthritis can also be suppressed {{see TANAKA, S., MURAKAMI, T., HORIKAWA, H., SUGIURA, M., KAWASHIMA, K., SUGITA, T., Suppression of arthritis by the inhibitors of dipeptidyl peptidase IV. Int. J. Immunopharmacol. 19, 15 (1997)}}.

It has also been found that, because of the associated temporary reduction in enzyme activity, administering stable inhibitors (effectors) of DP IV or of DP IV-analogous enzyme activity in the blood of a mammal causes reduced breakdown of the endogenous (or additionally exogenously administered) insulinotropic peptides gastric inhibitory polypeptides 1-42 (GIP₁₋₄₂) and glucagon-like peptide amides-1 7-36 (GLP-1₇₋₃₆) (or GLP-1₇₋₃₇ or analogues thereof) by DP IV

and DP IV-like enzymes and, accordingly, the drop in concentration of those peptide hormones or analogues thereof is reduced or delayed. The greater stability of the (endogenously present or exogenously introduced) incretins or analogues thereof, brought about by the action of the DP IV-effectors, which increases their availability for insulinotropic stimulation of the incretin receptors of the Langerhans cells in the pancreas, *inter alia* alters the effectiveness of the body's own insulin, resulting in stimulation of carbohydrate metabolism in the organism treated. As a result, the blood sugar level in the serum of the organism treated falls below the glucose concentration characteristic of hyperglycaemia. Consequently, by means of DP IV-inhibitors it is possible to prevent or alleviate metabolic anomalies, such as excess weight, glucosuria, hyperlipidaemia, and possible serious metabolic acidoses and diabetes mellitus, which are the result of prolonged elevated glucose concentrations in the blood {(see DE 196 16 486)}.

By means of DP IV-inhibitors it is also possible, experimentally, to prevent the penetration of CD 26 (DP IV) positive cells by HIV {(see WAKSELMAN, M., NGUYEN, C., MAZALEYRAT, J.-P., CALLEBAUT, C., KRUST, B., HOVANESSIAN, A.G., Inhibition of HIV-1 infection of CD 26+ but not CD26-cells by a potent cyclopeptidic inhibitor of the DPP IV activity of CD 26. Abstract P 44 of the 24th European Peptide Symposium 1996)}.

It has also been found that DP IV can modulate the activity of neuroactive peptides, such as neuropeptide Y and CLIP {(see MENTLEIN, R., DAHMS, P., GRANDT, D., KRUGER, R., Proteolytic processing of neuropeptide Y and peptide YY by dipeptidyl peptidase IV. Regul. Pept. 49, 133 (1993); WETZL, W., WAGNER, T., VOGEL, D., DEMUTH, H.-U., BALSCHUN, D., Effects of the CLIP fragment ACTH 20-24 on the duration of REM sleep episodes. Neuropeptides, 31, 41 (1997)}.

These varied actions of DP IV-inhibitors suggest that, when used in the case of a specific pathophysiological condition of a tissue, their actions can have an effect on other normal physiological states, for example in other organs. Those effects can have both positive and negative consequences for the target organism.

The problem of the present invention is accordingly to provide effectors of DP IV that have a high bioavailability of DP IV-inhibitors and a precisely defined duration of action in specific target tissues or target organs.

It was especially a problem of the present invention to provide inhibitors of DP IV that have a precisely defined short duration of action combined with high bio-availability.

SUMMARY OF THE INVENTION

The problems of the prior art are solved by the provision of compounds of unstable inhibitors of dipeptidyl peptidase IV (DP IV), which compounds have the general formula A-B-C, wherein

A is an amino acid,

B is a chemical bond between A and C or is an amino acid, and

C is an unstable inhibitor of DP IV.

When B represents a bond, it is especially a peptide bond; when B is an amino acid, it is preferably linked to A and C by way of peptide bonds.

The present invention accordingly relates to novel compounds of unstable inhibitors of the serine peptidase dipeptidyl peptidase IV, which compounds can be used in the treatment of various disorders, especially of metabolic disorders associated with diabetes mellitus.

Surprisingly such masked inhibitors are additionally considerably more effective than non-masked inhibitors: if identical amounts of non-masked DP IV-inhibitors and of compounds according to the invention are used, the compounds according to the invention produce a marked improvement in glucose tolerance in Wistar rats.

A further advantage of the compounds according to the invention lies in the fact that the onset of action and also the duration of action of the DP IV-inhibitors can be temporally controlled by suitable selection of the groups A-B. In particular, the release of the groups A-B from the compounds according to the invention depends upon the nature of the amino acid radical of A: in respect of the definition of group A, the following sequence has been found in particular for the rate at which the radicals A-B are released from the compounds A-B-C by DP IV:

Ile<Val<Phe<Pro<Ala<Gly. The rate constants of the corresponding DP IV-catalysed release are from 1 s^{-1} to 100 s^{-1} . A means is thus available for releasing the DP IV-inhibitors in a precisely temporally defined manner: -if the enzymes are to act immediately, for example upon intake of glucose-rich nutrient, a compound A-B-C will be selected that has, for example, the amino acid Gly as the A group; if the action of the inhibitor is to be delayed then the amino acid Ile, for example, can be selected as group A.

By means of the compounds according to the invention, it is thus possible for the DP IV-inhibitors to be transported through the mucosa of the small intestine especially virtually without delay, for example virtually simultaneously with nutrient intake.

Moreover, the site at which the DP IV-inhibitors are released and at which they act can also be controlled by the nature of the radicals A-B:

Various other amino peptidases, such as, for example, pyroglutamyl aminopeptidase and prolyl aminopeptidase, are present in the blood of mammals in addition to dipeptidyl peptidase IV. By suitable selection of the radicals A-B, it is possible according to the invention to determine the aminopeptidase by which the DP IV-inhibitor is to be released and so to determine where the action of the inhibitor is to occur. The compounds according to the invention or corresponding pharmaceutical compositions can thus also be used in cell-, tissue- or organ-specific inhibition of DP IV. The groups A-B can also be so selected that only those enzymes that are present only vascularly and that release the inhibitors at a sufficiently fast rate are targeted.

To summarise, it may be stated that by means of the compounds of unstable DP IV-inhibitors according to the invention, it is possible, in a completely surprising manner:

1. to achieve increased action of the inhibitors;
2. for the inhibitors to be released according to patients' needs;
3. for the inhibitors to be released from the compounds in a temporally controlled manner;
4. for the site at which the inhibitors are released from the compounds to be controlled;
5. for a reservoir of DP IV-inhibitors to be provided; and

6. for the duration of action or the end of action of the initiators to be precisely defined from the time of their unmasking.

According to the invention there are also provided pharmaceutical compositions especially for oral administration, ~~characterised~~characterized in that they comprise at least one compound according to the invention optionally in combination with customary carriers or excipients.

The compounds according to the invention or pharmaceutical compositions comprising them can be used in the treatment or prophylaxis of disorders in mammals that can be treated by modulating the DP IV activity of a mammal, such as, for example, metabolic disorders in humans.

In particular they can be used in the treatment of impaired glucose tolerance, glucosuria, hyperlipidaemia, metabolic acidoses, diabetes mellitus, diabetic neuropathy and nephropathy and sequelae of diabetes mellitus in mammals.

Because of the preferably short duration of action of the unstable inhibitors according to the invention, it is especially possible to ~~minimise~~minimize or prevent an influence upon processes in the human or animal body that would require long-term inhibition of DP IV.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features and advantages of the present invention will be more fully understood from the following detailed description of illustrative embodiments, taken in conjunction with the accompanying drawings in which:

Fig. 1 shows Structural formula of the product of the intramolecular cyclisation of H-Phe-Pro-pyridinium methyl ketone. The characteristic chemical displacements (in ppm) determined by means of ^{13}C NMR and ^1H NMR are assigned to the corresponding atoms.

Fig. 2 shows a MALDI-TOF mass spectra of the cyclisation of H-Phe-Pro-pyridiniummethyl ketone in an aqueous buffer solution pH = 7.6, recorded according to the incubation period.

Fig. 3 shows a MALDI-TOF mass spectra of the cyclisation of H-Val-Pro-pyridinium methyl ketone in an aqueous buffer solution pH = 7.6, recorded according to the incubation period

Fig. 4 shows UV spectra of an aqueous solution of H-Phe-Pro- pyridinium methyl ketone incubated in 0.1M HEPES buffer, pH = 7.6, at 30°C. The cyclisation reaction was monitored over a period of 40 minutes.

Fig. 5 shows a Progress curves of the DP IV-catalysed hydrolysis of the substrate H-Gly-Pro-*p*NA in the presence of 2.8×10^{-3} M H-Val-Pro-pyridiniummethyl ketone, 0.06 μ g/ml of DP IV, 4×10^{-4} M H-Gly-Pro-*p*NA in the batch, 0.1M HEPES buffer, pH = 7.6, 30°C.

Fig. 6 shows a Progress curves of the DP IV-catalysed hydrolysis of H-Gly-Pro-*p*NA in the presence of 2.1×10^{-4} M H-Phe-Pro-pyridinium methyl ketone, 0.06 μ g/ml of DP IV, 1.0×10^{-3} mol/litre of H-Gly-Pro-*p*NA in the batch, 0.1M HEPES buffer, pH = 7.6, 30°C.

Fig. 7 shows a MALDI-TOF mass spectrum of the incubation batch of the DP IV-catalysed hydrolysis of H-Gly-Pro-*p*NA in the presence of 2.6×10^{-5} mol/litre of H-Gly-Pro-Val-Pro-pyridinium methyl ketone, 0.06 μ g/ml of DP IV, 2.0×10^{-4} mol/litre of H-Gly-Pro-*p*NA, 0.1M HEPES buffer, pH = 7.6, 30°C. Recorded after an incubation period of 60 minutes.

Fig. 8 shows Progress curves of the DP IV-catalysed hydrolysis of H-Gly-Pro-*p*NA in the presence of 2.6×10^{-5} mol/litre of H-Gly-Pro-Val-Pro-pyridiniummethyl ketone, 0.06 μ g/ml of DP IV, 2.0×10^{-4} mol/litre of H-Gly-Pro-*p*NA in the batch, 0.1M HEPES buffer, pH = 7.6, 30°C.

DETAILED DESCRIPTION OF THE INVENTION

According to the invention, those compounds can be used as inhibitors of DP IV, it being possible for the site of their action, the time of onset of their action and the duration of action to be defined precisely:

Upon administration, the compounds are cleaved, for example by suitable enzymes, and the unstable "C" inhibitors are thus released by removal of the groups A-B. The inhibitors are released both by chemical and enzymatic mechanisms. For example, esterases, proteases and peptidases serve to release the active ingredient from compounds according to the invention. Such esterases, proteases, etc., are disclosed, for example, in WO 97/45117, US 5433955, US 5614379 and US 5624894.

The released unstable inhibitors can then interact with the DP IV already present and inhibit it. As a direct result, for example, the above-mentioned insulinotropic peptides are broken down to a lesser degree and the effectiveness of insulin is thereby increased.

The administration of unstable inhibitors of DP IV *per se* has proved disadvantageous for inhibiting DP IV since they are broken down very rapidly *in vivo* and thus uniform distribution of the inhibitors, especially in the human body, is impossible. In particular, upon oral administration such inhibitors are so unstable that they have virtually no activity at all. Accordingly, stable inhibitors have hitherto been used especially in the treatment of diabetes mellitus.

Surprisingly it has now been found that unstable "C" inhibitors can be ~~stabilised~~stabilized sufficiently by masking them as groups of the formula A-B-C.

That ~~stabilisation~~stabilization is also surprising insofar as a compound of formula A-B-C that has a carbonylmethyl pyridinium group is positively charged at the pyridinium nitrogen atom. As a result, electron-attraction is exerted by the methylene group upon the group that, after removal of the A-B radical, constitutes the active nucleophilic reaction centre of the inhibitor. On the basis of the resulting activation of the reaction centre, it would have been expected that its nucleophilic tendency would have been increased to such an extent that nucleophiles would "dock" non-specifically at the compound A-B-C and the inhibitor would be inactivated. Surprisingly it has been found, however, that such inactivation of the inhibitors does not occur.

In order to intervene by means of DP IV-inhibitors in physiological control circuits that require only a short-term effect upon the target enzyme DP IV, according to the invention there are

provided, for example, inhibitors as component C that have only a short duration of action and that after a definable half-life become chemical compounds that have no inhibitory activity.

For example, to strengthen the incretin effect in diabetes mellitus a duration of action of the inhibitors of a few minutes is sufficient whilst, for example, the suppression of the DP IV-mediated immune response in the case of transplantations requires long-term action by the inhibitors.

After being released, the unstable inhibitors according to the invention cyclise, for example, into a piperazine derivative and are thus inactivated. That reaction occurs spontaneously and is attributable to the nucleophilic action of the N-terminal amino nitrogen on the C-terminal carbonyl function of the dipeptide derivative and is facilitated by *cis/trans* isomerisation around the amino acid/imide bond, which isomerisation is facilitated especially in proline-containing peptides.

Moreover, that decomposition process does not begin until the compound has reached the desired target compartment, for example the blood circulation, and has begun the desired activity.

Those properties of the inhibitors according to the invention can be used according to the invention to design different DP IV-inhibitors in order to trigger the desired temporally defined deactivation of the DP IV-inhibitor by intramolecular cyclisation after it has been released.

In particular, according to the invention preference is given to compounds in which C is a dipeptide derivative having an active carbonyl group at the C-terminus. Preferably C is a dipeptidyl chloroalkyl ketone, dipeptidyl boronic acid or dipeptidyl cyanide compound or a dipeptidyl pyridinium methyl keto compound. Such inhibitors have proved to be especially effective unstable DP IV-inhibitors. There may be mentioned as examples of the dipeptide group, for example Ile-Thia, Ile-Pyr, Val-Thia and Val-Pyr. According to the invention, the inhibitors (component C) may also be present in salt form, with preference being given to organic salts, such as acetates, succinates, tartrates or fumarates, or to inorganic acid radicals, such as phosphates or sulphates. Special preference is given to fumarates.

According to a preferred embodiment of the present invention, compounds are used in which B is proline, hydroxyproline, thiazolidinecarboxylic acid, dehydro-proline, pipecolic acid, azetidinecarboxylic acid or aziridinecarboxylic acid, with proline and hydroxyproline being especially preferred.

In particular, the compounds according to the invention also have the advantage that the inhibitors of DP IV are released according to individual patients' needs:

When a compound according to the invention interacts with a DP IV molecule, it is cleaved by the enzyme into the groups A-B and the inhibitor C. The inhibitor C will inhibit the DP IV molecule so that it cannot cleave any further compounds. If further DP IV molecules are present, the compounds will continue to be cleaved (if a sufficient amount of corresponding compounds has been administered) until the last DP IV molecule has been inhibited. The remaining compounds are not broken down and thus constitute an inhibitor reservoir until the concentration of DP IV molecules rises again or inhibitor molecules are displaced by the DP IV or inhibitor molecules are eliminated or inactivated, and the compounds according to the invention are then cleaved again, thus releasing inhibitors.

The invention also has the further advantage that each organism will release the exact amount of inhibitor that is necessary to inhibit the amount of DP IV present, which is different in individual cases. If, for example, a patient has a high concentration of DP IV then a large amount of inhibitor will be released; if there is only a slightly elevated concentration of DP IV, only a small amount of inhibitor will be released.

In particular, special preference is given to compounds in which A-B is a dipeptide of the formula Ile-Pro or Gly-Pro.

Embodiments

Synthesis of unstable DP IV-inhibitors C and compounds of unstable DP IV-inhibitors according to the invention (A-B-C)

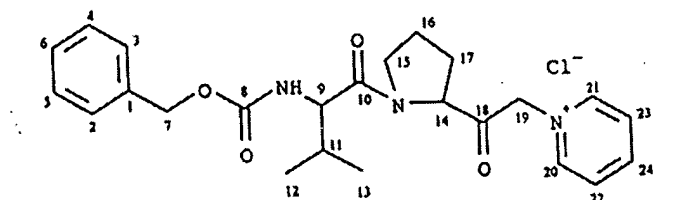
The preparation of unstable DP IV-inhibitors C (corresponding to the general formula A-B-C) is shown in Examples 1.1 and 1.2. The synthesis of a compound of unstable DP IV-inhibitors

according to the invention is shown in Example 1.3. The starting materials, the corresponding peptidyl chloromethyl ketones in each case, were prepared according to known processes (WEINSTEIN, B., Chemistry and Biochemistry of Amino Acids, Peptides, and Proteins, Marcel Dekker, New York, Basle, 1977). The pyridinium methyl ketones prepared by way of example under 1.1. and 1.2, which are N-terminal-protected dipeptide derivatives, are extremely stable and can be ~~characterised~~characterized completely. At normal air humidity, the N-terminal deblocked dipeptide derivatives begin the intramolecular decomposition process immediately after being deblocked, so that it is not possible to determine a melting point. The products are characterised by means of HPLC and mass spectrometry.

1.1 Synthesis of H-Val-Pro-CH₂-(N⁺C₅H₅)/Cl⁻

a) Z-Val-Pro-CH₂- (N⁺C₅H₅)/Cl⁻

Structural formula:



Preparation: 10 mmol of Z-Val-Pro-chloromethyl ketone are dissolved in pyridine and stirred at 25°C for 5 days. The excess pyridine is distilled off at 2 mbar vacuum. The Z-Val-Pro-pyridinium methylketone is subjected to HPLC purification. The compound is an oil.

Empirical formula: C₂₄H₃₀N₃O₄Cl

Molecular weight: 459.97 Da

Yield: 45.8 % of the theory

HPLC: retention time: 2.3 min, LiChrosper 100

RP-18 (125-4), λ 220 nm, flow rate

0.5 ml/min, isocratic 50% acetonitrile

in H₂O) (0.1% TFA)

retention time: 19.3 min, Nucleosil 7

C₈, λ = 220 nm, flow rate 8 ml/min,

isocratic 50 % acetonitrile in H₂O

(0.1% TFA)

¹H NMR (DMSO-d₆) δ_H: 0.8-1.0 (6H, m, H₁₂ and H₁₃), 1.8-2.1

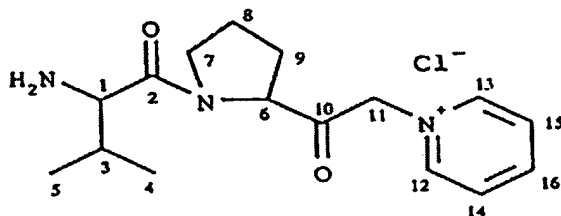
(3H, m, H₁₁ and H₁₆), 2.2-2.4 (2H, m, H₁₇), 3.4-3.7 (2H, m, H₁₅),
3.7-4.1 (2H, m, H₂₀ and H₂₁), 4.3-4.5 (1H, dd, 5 Hz, 8 Hz, H₉),
4.8-5.1 (2H, m, H₂), 5.8-6.2 (3H, m, H₁₄, H₁₉), 7.2-7.5. (5H, m,
H₂-H₆), 8.2-8.3 (2H, m, H₂₂ and H₂₃), 8.6-8.7 (1H, m, H₂₄), 8.8-9.0
(1H, d, 6 Hz, NH)

¹³C NMR (DMSO-d₆) δ_C: 136.8 (C₁), 127.9 (C₂, C₃), 127.8 (C₄, C₅), 128.4 (C₆), 66.7 (C₇),
156.3 (C₈), 57.9 (C₉), 170.8 (C₁₀), 29.7 (C₁₁), 18.5 (C₁₂, C₁₃), 63.7
(C₁₄), 47.2 (C₁₅), 25.1 (C₁₆), 27.9 (C₁₇), 200.3 (C₁₈), 71.1. (C₁₉),
146.1 (C₂₀, C₂₁), 128.3 (C₂₂, C₂₃), 146.4 (C₂₄)

MALDI-TOF-MS m/z: 424.6 Da (M+H⁺, without chloride anion)

b) H-Val-Pro-CH₂- (N⁺C₅H₅)/Cl⁻

Structural formula:



Preparation: The Z-protecting group is removed from Z-Val-Pro-CH₂-(N⁺C₅H₄)/Cl⁻ by means of HBr/glacial acetic acid in a reaction time of 5 minutes. 2 ml of HBr/glacialacetic acid (33%) are added to 1.0 mmol of Z-protected peptide and the mixture is stirred at 23°C for approx. 10 min. Concentration *in vacuo* is then carried out. The peptide is precipitated in the form of the hydrobromide from methanol by means of diethyl ether, suction-filtered and dried *in vacuo*. Empirical formula: C₁₆H₂₄N₃O₂Cl

Molecular weight: 325.84 Da

Yield: 97.7 % of the theory

HPLC: retention time: 7.4 min, LiChrosper 100

RP-18 (125-4), λ = 220 nm, flow rate

0.5 ml/min, isocratic 50% acetonitrile

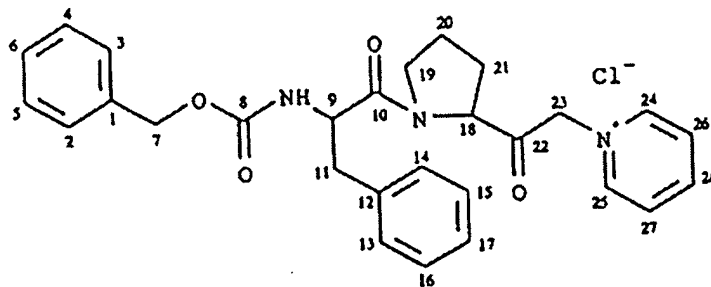
in H₂O (0.1% TFA)

MALDI-TOF-MS m/z: 291.2 Da (M+H⁺, without chloride anion)

1.2 Synthesis of H-Phe-Pro-CH₂ - (N⁺C₅H₅)/Cl⁻

a) Z-Phe-Pro-CH₂- (N⁺C₅H₅)/Cl⁻

Structural formula:



Preparation: 2 ml of pyridine are added to 10 mmol of Z-Phe-Pro-chloromethyl ketone. The mixture is stirred at 23°C for 4 days. The excess pyridine is distilled off at 2 mbar vacuum. The crude product is purified over 60 g of silica gel. In the chloroform/methanol eluate (9:1 parts by volume) initially the product is collected and, as the polarity of the eluant increases, the chloromethyl ketone is collected. Z-Phe-pro-pyridinium methyl ketone is finally subjected to HPLC purification. Empirical formula: $C_{28}H_{30}N_3O_4Cl$

Molecular weight: 508.01 Da

Yield: 69.6 % of the theory

HPLC: retention time: 17 min, LiChrosorb RP-8

(Hibar), $\lambda = 220$ nm, flow rate

8.0 ml/min, isocratic 50 % acetonitrile

in H_2O (0.1% TFA)

retention time: 3.4 min, LiChrosper RP- 8

(125*4), $\lambda = 220$ nm, flow rate

1.5 ml/min, gradient 30-80%

acetonitrile in H_2O (0.1% TFA) in

25 min

retention time: 10.2 min, Nucleosil 7

C₈, λ = 220 nm, flow rate 8 ml/min,

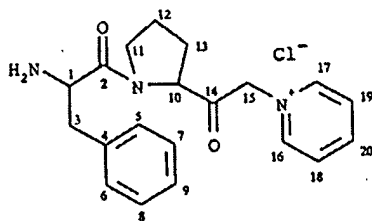
isocratic 50% acetonitrile in H₂O (0.1% TFA)

¹H NMR (DMSO-d₆) δH: 1.7-2.1 (4H, m, H₂₀, H₂₁), 2.7-3.0 (2H, m, H₁₁), 3.4-3.9 (2H, m, H₁₉), 4.4-4.6 (1H, m, H₉), 4.6-4.8 (2H, m, H₂₄, H₂₅), 5.0-5.1 (2H, dd, H₇), 5.7-5.8 (1H, d, H₁₈), 5.9-6.1 (2H, dd, H₂₃), 7.2-7.4 (10H, m, H₂-H₆, H₁₃-H₁₇), 8.6-8.8 (1H, dd, H₂₈), 8.2-8.3 (2H, d, H₂₆ and H₂₇), 8.8-8.9 (1H, d, NH)

¹³C NMR (DMSO-d₆) δ_C: 136.8 (C₁), 127.9 (C₂, C₃), 127.6 (C₄, C₅), 128.4 (C₆), 65.5 (C₇), 156.3 (C₈), 54.1 (C₉), 170.9 (C₁₀), 36.4 (C₁₁), 137.6 (C₁₂), 126.6 (C₁₃, C₁₄), 128.4 (C₁₅, C₁₆), 129.3 (C₁₇), 63.1 (C₁₈), 46.9 (C₁₉), 25.1 (C₂₀), 27.6 (C₂₁), 200.7 (C₂₂), 66.3 (C₂₃), 146.2 (C₂₄, C₂₅), 128.2 (C₂₆, C₂₇), 146.4 (C₂₈) MALDI-TOF-MS m/z: 472.8 Da (M+H⁺, without chloride anion)

(b) H-Phe-Pro-CH₂-(N⁺C₅H₅)/Cl⁻

Structural formula:



Preparation:

The Z-protecting group is removed from

———Z-Phe-Pro-CH₂-(N⁺C₅H₄)/Cl⁻ after a

———reaction time of 5 minutes. 2 ml of

——HBr/glacial acetic acid (33%) are added
——to 1.0 mmol of Z-protected peptide and
——the mixture is stirred at 23°C for
——approx. 10 minutes. Concentration *in*
——*vacuo* is then carried out. The peptide
——is precipitated in the form of the
——hydrobromide using diethyl ether,
——suction-filtered and dried *in vacuo*.

Empirical formula: $C_{20}H_{24}N_3O_2Cl$

Molecular weight: 373.88 Da

Yield: 98 % of the theory

HPLC: retention time: 6.9 min, LiChrosper 100

RP-18 (125-4), $\lambda = 220$ nm, flow rate

0.5 ml/min, isocratic 50% acetonitrile

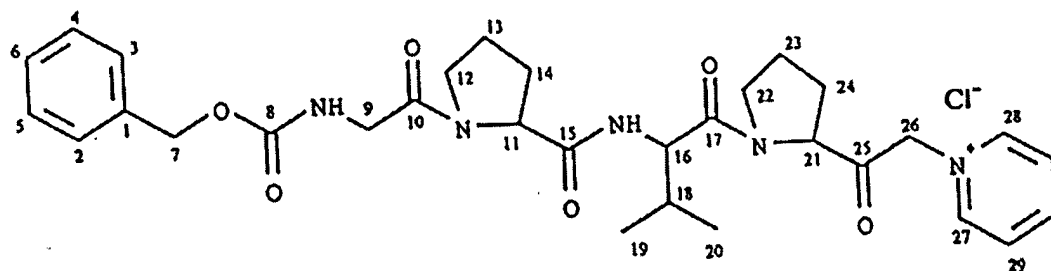
in H₂O (0.1% TFA)

MALDI-TOF-MS m/z: 337.2 Da ($M+H^+$, without chloride anion)

1.3 Synthesis of H-Gly-Pro-Val-Pro-CH₂- ($N^+C_5H_5$)/Cl⁻

a) Z-Gly-Pro-Val-Pro-CH₂- ($N^+C_5H_5$)/Cl⁻

Structural formula:



Preparation: 2 ml of pyridine are added to 10 mmol of Z-Gly-Pro-Val-Pro-chloromethylketone. The mixture is stirred at 23°C for 4 days. The excess pyridine is distilled off at 2 mbar vacuum. Z-Gly-Pro-Val-pro-pyridinium methyl ketone is subjected to HPLC purification. Empirical formula: $C_{31}H_{40}N_5O_6Cl$

Molecular weight: 614.14 Da

HPLC: retention time: 17.4 min, LiChrosorb RP

8 Hibar, $\lambda = 220$ nm, flow rate 8 ml/min,

isocratic 50% acetonitrile in H_2O (0.1%

TFA)

retention time: 5.4 min, LiChroCART 100

RP-18 (250-4), $\lambda = 220$ nm, flow rate

0.5 ml/min, isocratic 50% acetonitrile

in H_2O (0.1% TFA)

retention time: 17.7 min, Nucleosil 100

7 C₈, $\lambda = 220$ nm, flow rate 5 ml/min,

isocratic 50% acetonitrile in H₂O (0.1%

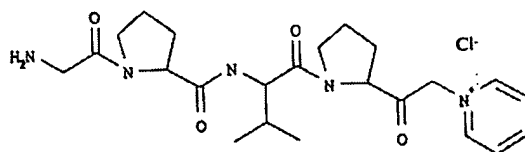
TFA)

¹³C NMR (DMSO-d₆) δ_C: 134.4 (C₁), 128.9 (C₂, C₃), 128.2 (C₄, C₅), 129.8 (C₆), 65.3 (C₇), 157.2 (C₈), 39.0 (C₉), 165.7 (C₁₀), 56.0 (C₁₁), 41.6 (C₁₂), 24.6 (C₁₃), 29.0 (C₁₄), 170.5 (C₁₅), 52.1 (C₁₆), 171.9 (C₁₇), 30.3 (C₁₈), 18.6, 19.3 (C₁₉, C₂₀), 58.9 (C₂₁), 47.2 (C₂₂), 25.0 (C₂₃), 29.4 (C₂₄), 196.5 (C₂₅), 65.8 (C₂₆), 137.9 (C₂₇, C₂₈), 129.1 (C₂₉, C₃₀), 146.5 (C₃₁)

MALDI-TOF-MS m/z: 579.7 Da (M+H⁺, without chloride anion)

b) H-Gly-Pro-Val-Pro-CH₂- (N⁺C₅H₅)/Cl⁻

Structural formula:



Preparation: The Z-protecting group is removed from Z-Phe-Pro-CH₂-(N+C₅H₄)/Cl⁻ after a reaction time of 5 minutes. 2 ml of HBr/glacial acetic acid (33%) are added to 1.0 mmol of Z-protected peptide and the mixture is stirred at 23°C for approximately 10 minutes. Concentration *invacuo* is then carried out. The peptide is precipitated in the form of the hydrobromide using diethyl ether, suction-filtered and dried *in vacuo*. Empirical formula: C₂₃H₃₄N₅O₄Cl

Molecular weight: 480.0 Da

Yield: 95 % of the theory

MALDI-TOF-MS m/z: 443.9 Da (M+H⁺, without chloride anion)

BREAKDOWN OF UNSTABLE DP IV-INHIBITORS AND OF THEIR MASKED FORMS IN AQUEOUS SOLUTION

To ~~analyse~~analyze the stability of the inhibitors prepared under 1.1 and 1.2, the inhibitors were incubated in an aqueous buffer solution and their intramolecular cyclisation reaction was monitored by means of MALDI-TOF mass spectrometry (Figures 2 and 3). The products of that reaction are the respective pyrazine derivatives (Figure 1).

The breakdown of H-Phe-Pro-pyridinium methyl ketone having the molecular weight of 337.2 Da to the cyclic pyrazine derivative having the molecular weight of 319.2 Da, with removal of water, is completed quantitatively within a period of 30 minutes (Figure 2).

The breakdown of H-Val-Pro-pyridiniummethyl ketone having the molecular weight of 291.2 Da to the cyclic pyrazine derivative having the molecular weight of 273.2 Da, with removal of water, is completed quantitatively within a period of 60 minutes (Figure 3).

The formation of the double bond system of the pyrazine, which takes place during the intramolecular reaction, enables quantitative analysis of the cyclisation process by means of UV spectrometry (Figure 4). The rate constants determined therefrom for the intramolecular cyclisation of unstable DP IV-inhibitors in 0.1M HEPES buffer, pH = 7.6, 25°C, are shown in Table 1.

Table 1: PARAMETERS OF THE CYCLISATION OF UNSTABLE DP IV-INHIBITORS

Compound	$k \text{ min}^{-1}$	Half life (min)
H-Val-Pro-CH ₂ -(N ⁺ C ₅ H ₅)	$8.7 \times 10^{-4} (\pm 4 \times 10^{-5})$	13.3
H-Phe-Pro-CH ₂ -(N ⁺ C ₅ H ₅)	$1.2 \times 10^{-3} (\pm 3.9 \times 10^{-5})$	9.6

In contrast thereto, the compounds H-Val-Pro-CH₂-(N⁺C₅H₅) ~~and in the form of~~
H-Gly-Pro-Val-Pro-CH₂-(N⁺C₅H₅) according to the invention ~~have~~ has proved to be
completely stable over a period of 24 hours under identical conditions.

**INTERACTION OF UNSTABLE DP IV-INHIBITORS OR COMPOUNDS
COMPRISING DIPEPTIDYL PEPTIDASE IV ACCORDING TO THE
INVENTION IN AQUEOUS SOLUTION**

When the DP IV target enzyme is incubated with unstable inhibitors in the presence of a substrate, inhibition of the enzyme is observed initially; the inhibition subsides again as the experimental time progresses as a result of the intramolecular cyclisation of the inhibitor which takes place in parallel, since the concentration of the inhibitor in the reaction solution decreases as a result of the spontaneously occurring chemical reaction. That effect is shown in Figures 5 and 6. Because of the time-dependent drop in the concentration of the inhibitor, the rate of the enzyme-catalysed hydrolysis of the substrate increases again as time progresses.

In contrast to the non-masked DP IV-inhibitors, the compound H-Gly-Pro-Val-Pro-CH₂-(N⁺C₅H₅) according to the invention has proved to be stable over a period of 24 hours in buffered aqueous solution in the absence of an enzyme. The active DP IV-inhibitor H-Val-Pro-CH₂-(N⁺C₅H₅) is released only as a result of the addition of the DP IV enzyme (used here by way of example also to release the DP IV-inhibitor) with removal of the N-terminal dipeptide H-Gly-Pro-OH. Accordingly, in the mass spectrum (Figure 7) markedly more than 50% of the incubated compound according to the invention can be detected even after an incubation period of 60 minutes. Owing to that delayed release, surprisingly there is also observed, in addition to the desired effective inhibition of the target enzyme, a markedly prolonged activity combined with markedly reduced concentration of the compound according to the invention compared with the unstable DP IV-inhibitors as shown in Figure 8.

ABSTRACT OF THE DISCLOSURE

Novel compounds of unstable inhibitors of the serine peptidase dipeptidyl peptidase IV, are used in the treatment of various disorders, especially of metabolic disorders. The compounds can be used in the treatment of impaired glucose tolerance, glucosuria, hyperlipidaemia, metabolic acidoses, diabetes mellitus, diabetic neuropathy and nephropathy.